Optical and morphological properties of Ag nanoparticles synthesized by *Artemisia lerchiana* W. extract

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The development of green synthesis of nanoparticles has attracted attention due to its easy preparation, less chemical processing and eco-friendly nature. Synthesis of metal nanoparticles using plant extracts is one of the simplest, convenient, economical and eco-friendly methods that reduce the impact of toxic chemicals. Thus, in recent years, eco-friendly processes for the rapid synthesis of silver nanoparticles using aqueous extracts of plant parts such as leaves, bark, roots, etc. have been reported. *Artemisia lerchiana* is a widely used medicinal plant due to its bioactive compounds. This article targets a bio-oriented audience and summarizes the methods used in their characterization. In the study, silver nanoparticles (AgNPs) were successfully synthesized via green synthesis using $AgNO_3$ (silver solution), and *Artemisia lerchiana* plant. The structures of the synthesized silver nanoparticles were elucidated by UV-Vis, TEM and Zeta potential spectroscopic analyses. The UV-vis spectra showed an absorption at 480 nm. TEM analysis showed that the particles were spherical in nature with a size distribution ranging from 4-19 nm. Zeta size and zeta potential analyses revealed that the average size distribution of AgNPs was 165 nm and the surface charge was -20 mV.

Keywords: *Green synthesis, Artemisia lerchiana* W.*, UV-visible spectroscopy, Transmission electron microscopy (TEM), Zeta-potential*

INTRODUCTION

The field of nanotechnology research has made significant progress over the past few decades and has emerged as a promising technology in the scientific field, particularly in the development of materials with potential medical applications (Ahmad et al., 2022). Nanotechnology has emerged as a promising field in cancer therapy, offering the potential for targeted drug delivery systems that can enhance the efficacy of chemotherapeutic agents while reducing their systemic toxicity (Zhang H., et al., 2023). Silver nanoparticles (AgNPs) have garnered attention in this context due to their unique physicochemical properties, including their small size, large surface area to mass ratio, and the ability to be functionalized with a variety of biological molecules. It is worth noting that AgNPs can generate reactive oxygen species (ROS) that cause DNA damage in cancer cells and induce cell death. AgNPs also show significant anticancer activities at very low doses, which reduces the risk of side effects. They can be presented to induce cancer cell death through targeted approach mechanisms. These properties facilitate the targeted delivery of drugs to cancer cells and the controlled release of therapeutic agents (Behboodi et al., 2019).

While the synthesis of AgNPs holds great promise for biomedical applications, conventional methods often rely on toxic chemicals that raise significant environmental and biological concerns (Manik et al., 2020). To address these issues, green synthesis methods have been developed as a sustainable alternative, leveraging biological agents to facilitate the reduction of silver ions to nanoparticles (Gengan et al., 2013).

Among various biosynthesized metallic NPs, AgNPs are emerged as the champion in the last two decades due to their unique biological, chemical, and physical properties (Shehwaz et al., 2021). Although Ag is toxic at higher concentrations, many studies have established that this element in the form of AgNPs and at a lower concentration has the desired chemical stability, high catalytic activity, good biocompatibility, and intrinsic therapeutic potential (Meena et al., 2020). AgNPs are also reported to have anticancer and antimicrobial activity (Remya et al., 2015). In fact, a slow and regulated release of Ag from AgNPs is one of the most striking advantages of these NPs when compared with the bulk metal and their salts (Alkhulaifi et al., 2020). A combination of nanotechnology and traditional medicine is the

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mantra of the new-age bio-nanoformulations.

In particular, AgNPs are synthesized via a variety of processes, including electrochemical and photochemical reductions, heat evaporation, and biological techniques (Vishwanath et al., 2017). However, these conventional techniques are extremely costly and also involve the use of dangerous chemicals which cause many threats to human health and the environment. Therefore, the synthesis of AgNPs based on natural sources such as microbial and plant extracts is receiving great attention because they are cheaper and environmentally friendly (Singh et al., 2018). Since there is no risk of bacterial or chemical contamination, there is less energy consumption with broader consequences, and it is simpler and easier to use plant materials for AgNP production than bacterial and chemical techniques.

MATERIALS AND METHODS

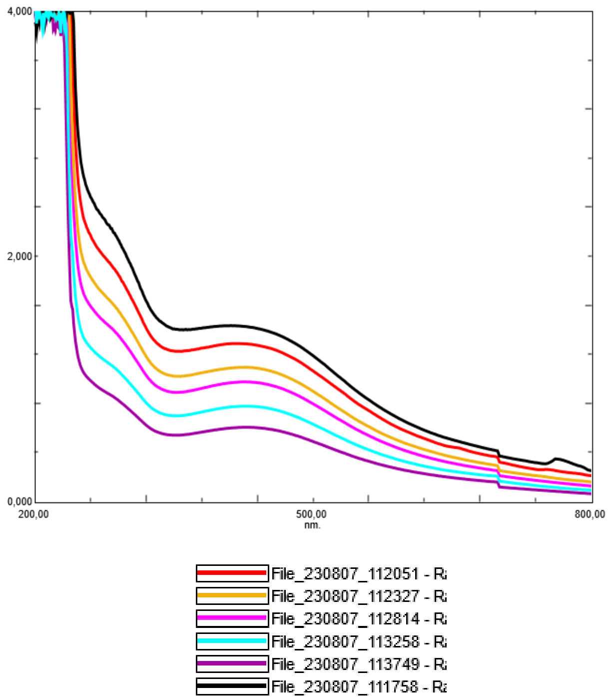
Preparation of wormwood extract and silver nitrate ($AgNO_3$) solution: In order to get the plant extract have been used the vegetative organs of *Artemisia lerchiana* Web. Plant samples were collected from the Lokbatan settlement of the Absheron region of Azerbaijan in the summer season. The samples were washed several times first with tap water and then with distilled water. The leaves of plant samples were dried in room conditions for 48 hours. 50 g of dried plant leaves were placed in a 500 ml beaker, then 250 ml of distilled water was added, and the mixture was boiled. The mixture is boiled for 5 minutes to get the desired result. Then the extract was cooled to room temperature. Filtering of the plant extract was done with No. 1 Whatman filter paper. The obtained extract was stored at +4°C until experiments. In order to obtain silver NPs, a solution of silver nitrate was prepared in the following proportion: 25 grams of salt were dissolved in 300 ml of distilled water.

Biosynthesis: 50 ml extract of wormwood leaves and 250 ml $AgNO_3$ solution were placed in a 1000 ml flask and reacted at 45°C after just shaking by hand. The reaction mixture was found to change color with time. The extract obtained as a result of the reaction was centrifuged at 6000 rpm for 15 minutes with an OHAUS FC 5706 device. After several washings, the precipitated solid was dried in an oven at 75°C for 24 h. The obtained particles were then prepared for characterization. Phytochemicals in plant extracts reduced Ag^{+1} to Ag^0, thus forming AgNPs.

RESULTS AND DISCUSSION

UV-visible spectroscopy analysis: The visible color change in AgNPs requires the reduction of Ag ions in nitrate ($AgNO_3$). The reaction mixture containing $AgNO_3$ and *Artemisia lerchiana* extract resulted in the formation of *Artemisia lerchiana* - AgNPs, which turned into a dark color as shown in Figure (1a). UV-vis spectral analysis is used to obtain information about AgNPs. In the absorption spectrum of AgNPs, the resonance band of the hazard plasmon appears in a wide range of 200–800 nm, with a strong absorption band observed at 480 nm (Agilent CARY 60) (Figure 1b).

(a)



(b)

Fig. 1. (a) Color change during synthesis of silver nanoparticles. (A) Yellowish AgNPs of *Artemisia lerchiana* at the start of the reaction. (B) Blackish Brown AgNPs of *Artemisia lerchiana* at the end of the reaction. (b) Maximum absorbance value with UV-vis spectrophotometer as a result of the interaction of *Artemisia lerchiana* plant extract and $AgNO_3$ solution

In various studies, the process of conversion of Ag^+ ions into AgNPs has been confirmed using UV-Vis spectroscopy. The addition of *Tamarix* leaf extract to silver nitrate solution caused a wide range of color changes from colorless to yellowish and finally reddish brown due to exposure to different times and amounts of extract within the reaction. The absorption spectra of *Tamarix*-AgNps were recorded 24 h after their preparation and the peak of the absorption spectra was found to be at 413 nm, which is characteristic for silver nanoparticles (Shehwaz et al., 2021). Spectral analysis of *S. alexandrina* leaf extract revealed the highest absorbance at 490 nm, indicating the successful conversion of silver nitrate (Ag^+) into silver nanoparticles (Alharbi et al., 2023). The formation of silver nanoparticles in *Hagenia abyssinica* (Bruce) J.F.Gmel leaf extract was confirmed by peaks observed in the range of 400–430 nm (Walelign et al., 2021). The presence of nanoparticles in the leaf extract of Capparis spinosa L. was confirmed by obtaining a spectrum in the visible range of 300 nm-600 nm using a UV-visible spectrophotometer. From this analysis, an absorbance peak at 420 nm was found, which is characteristic of Ag nanoparticles (Benakashani et al., 2016).

Transmission electron microscopy analysis

The result obtained from transmission electron microscopy (TEM) (HITACHI 7700) shows the dispersion, size and morphology of the synthesized AgNPs green synthesized *Artemisia lerchiana*. The surface morphology and size of the AgNPs were characterized by TEM analysis. It was clear from the low and high-resolution TEM images that the nanoparticles were naturally highly stable, small in size, monodisperse and spherical in shape, with a smooth surface without agglomeration. The high-resolution images showed that the nanoparticles were less than 50 nm in size and the average particle size was 4-19 nm.

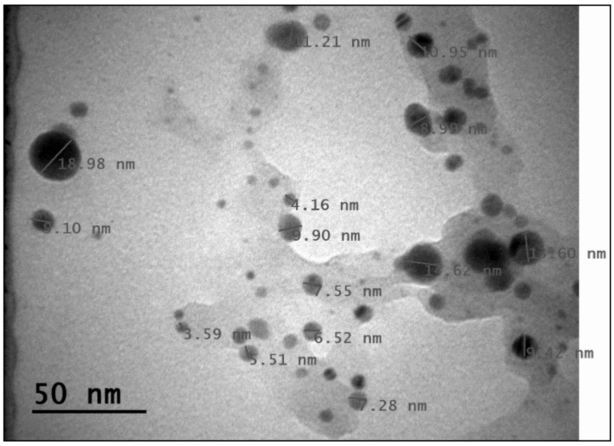
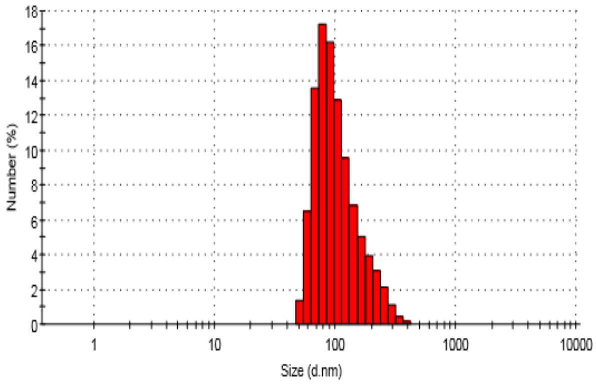


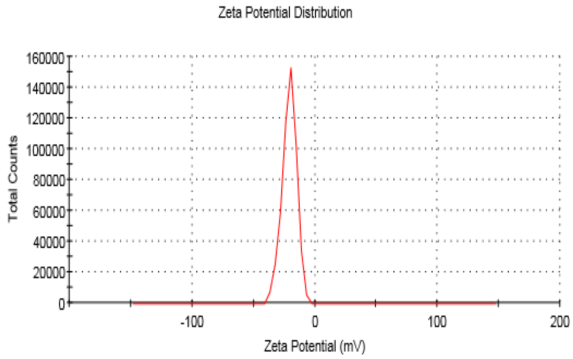
Fig. 2. TEM image of AgNPs obtained from *Artemisia lerchiana* plant extract at 50 nm

TEM image of silver nanoparticles synthesized from *Capparis spinosa* L. leaf extract showed that the nanoparticles were spherical in shape. The size of the spherical silver nanoparticles ranged from 5 to 30 nm, confirming the presence of nanoparticles. The dark-shaded coating on the surface of the nanoparticles indicated the presence of secondary materials. This could be attributed to the biocompounds present in the leaf extract (Benakashani et al., 2016).

Zeta potential analysis: Zeta potential is an important parameter for characterizing the stability of aqueous Ag-NPs suspensions. Zeta size and zeta potential analyses were performed to determine the surface charges and size distributions of the biosynthesized AgNPs, and it was found that the average size distribution of AgNPs was 165 nm and the surface charge was -20 mV (Figure 3a and 3b).



(a)



(b)

Fig. 3. (a) Zeta potential analysis of silver nanoparticles synthesized by aqueous extract of *A.lerchiana;* (b) Size analysis of silver nanoparticles synthesized by aqueous extract of *A.lerchiana* .

There is no standard size for the synthesis of nanoparticles, and nanoparticles of various sizes can be synthesized. Remya et al. (2015), Alkhulaifi et al. (2020), and Singh et al. (2018) reported the average sizes of nanoparticles as 27–32 nm, 59.74 nm, and 5–10 nm, respectively. On the other hand, the fact that the synthesized AgNPs only exhibited

negative charge distribution is an important indication that the AgNPs are stable. AgNPs synthesized by the green route show better negative charge distribution compared to conventional (chemical and physical) synthesis studies.

CONCLUSION

The green synthesis method we used is a low-cost approach and is capable of synthesizing AgNPs at room temperature. The size and structure of the obtained NPs were characterized by UV-visible spectroscopy, TEM and Zeta Potential analyses. UV-visible spectroscopy revealed an adsorption peak at 480 nm, confirming the formation of nanoparticles. TEM analysis showed that the nanoparticles were spherical in shape and had an average size of 4-19 nm. Zeta potential measurements demonstrated that the particles had high colloidal stability, which prevented their aggregation. Our results showed that plant leaf extract is a facile, economical and environmentally friendly way to synthesize metal nanoparticles. Furthermore, the plant-mediated synthesis method represents a significant improvement in the preparation of AgNPs, as it has various advantages such as reducing the reaction time and better control over their size and shape.

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Artemisia lerchiana W. ekstraktı vasitəsilə sintez edilmiş Ag nanohissəciklərin optik və morfoloji xüsusiyyətləri

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Nanohissəciklərin yaşıl sintezinin inkişafı ekoloji cəhətdən təmiz olması ilə diqqət çəkmişdir. Metal nanohissəciklərin bitki ekstraktlarından istifadə edilməklə sintezi zəhərli kimyəvi maddələrin təsirini minimuma endirən sadə, rahat, qənaətcil və ekoloji cəhətdən təhlükəsiz üsullardan biri hesab olunur. Son illərdə yarpaq, qabıq, kök və digər bitki hissələrinin sulu ekstraktlarından istifadə etməklə gümüş nanohissəciklərin (AgNPs) sürətli sintezini təmin edən ekoloji proseslər geniş şəkildə tədqiq olunmuşdur. *Artemisia lerchiana* bioaktiv birləşmələri sayəsində müxtəlif sahələrdə geniş istifadə olunan dərman bitkisidir. Bu tədqiqat bio-yönümlü auditoriyanı hədəfləyir və nanohissəciklərin xarakterizasiyasında istifadə olunan metodları ümumiləşdirir. İş çərçivəsində AgNP-lər *Artemisia lerchiana* bitkisinin ekstraktından və $AgNO_3$ (gümüş nitrat) məhlulundan istifadə etməklə yaşıl sintez metodu ilə uğurla sintez edilmişdir. Sintez edilən gümüş nanohissəciklərinin struktur xüsusiyyətləri UV-Vis spektroskopiyası və Zeta potensial və TEM analizi vasitəsilə tədqiq olunmuşdur. UV-Vis spektrləri 480 nm-də maksimum udma göstərmişdir. TEM (transmissiya elektron mikroskopiyası) analizi hissəciklərin sferik formaya malik olduğunu və ölçülərinin 4-19 nm diapazonunda dəyişdiyini aşkar etmişdir. Zeta potensial analizi isə nanohissəciklərin orta ölçülü paylanmasının 165 nm, səth yükünün isə -20 mV olduğunu müəyyən etmişdir.

***Açar sözlər**: Yaşıl sintez, Artemisia lerchiana* W., *UV-görünən spektroskopiya, Transmissiya elektron mikroskopiyası (TEM), Zeta-potensial*

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